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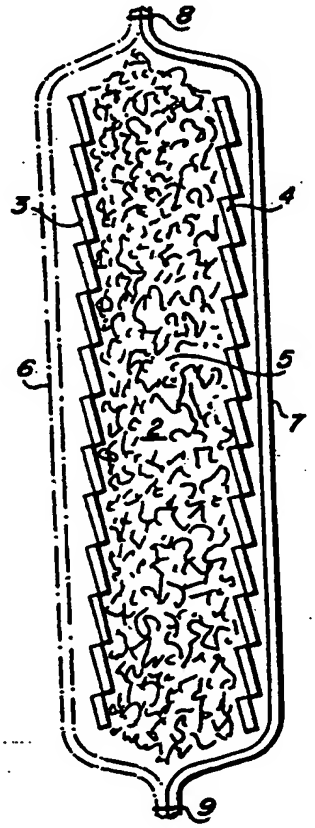
(54) Title: ANTI-EXPLOSION PADS AND THEIR METHOD OF USE

(57) Abstract

A highly efficient anti-explosion pad (6, 7) comprising multiple sheets of expanded metal net (10) separated by a core layer of porous material such as fiberglass, cotton batting or an assembly of miniature balls (22, 23, 24) formed from expanded metal net. When covering a wall or other structural element, the stratiform pad effectively dissipates the shock waves and thermal effects of a close range bomb explosion.



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ANTI-EXPLOSION PADS AND THEIR METHOD OF USE

This application claims the priority of United States of America application Serial No. 07/784,171, filed October 25, 1991.

FIELD OF THE INVENTION

This invention relates generally to anti-explosive pads which may be used to protect structures against the disastrous effects of accidental or otherwise unwanted explosions. More particularly, the invention involves stratiform anti-explosion pads including multiple layers of lightweight expanded metal net. The invention also involves the method of applying such pads for taking advantage of their anti-explosive characteristics.

BACKGROUND

As is well known, the production and use of explosives is an extensive and far-reaching industry. Research through the centuries has developed many useful applications for the known explosives, including the industrial blasting utilized in the mining and road building industries, as well as the harnessing of tiny explosions for use in internal combustion engines. The military use of gun powder and

other explosives in rifles, artillery, bombs and the like is also well known.

Concurrently with the benefits derived from the useful application of explosives, the world has been forced to endure the disastrous results which too often occur when explosives are accidentally detonated, such as in the case of explosions in coal mines, fuel tank fields, homes, automobiles, ships, airliners, and the like. Similarly, the world is faced with incidents in which bombs are used for terrorist or other illegal purposes.

There has been a considerable effort to develop products and methods for protecting structures against the destruction which occurs when explosives are detonated in their vicinity, either accidentally or for sinister purposes. Although some progress has been made, the loss of human lives and the destruction of property from explosions continues at an unacceptable rate, and there is continued intense effort to find practical, effective and economical ways of improving anti-explosive products and techniques.

It is an object of the present invention to provide a padding material which possess significantly enhanced explosion suppressing properties.

It is another object of the invention to produce an anti-explosion pad containing extremely lightweight components which serve in a surprisingly effective manner to dissipate the shock waves resulting from the detonation of an explosive material.

It is a further object to provide methods for use of the new anti-explosion pad in the protection of structures which are otherwise subject to severe damage from the explosive force of a detonated bomb.

Other objects and advantages will become apparent as the specification proceeds.

SUMMARY OF THE INVENTION

This invention is based on the discovery that walls and other structural elements can be effectively protected against bomb explosions by interposing between them and the bomb a lightweight pad containing multiple sheets of expanded metal net separated by a layer of porous material. It has been found that the presence of the expanded metal net effectively deflects and dissipates the shock waves resulting from the detonation of the explosive material, so that the wall or other structural element maintains its physical integrity in spite of the explosion.

The product of the present invention therefore is a stratiform anti-explosion pad comprising a first sheet of expanded metal net, a second sheet of expanded metal net, and an inner core layer of air-permeable material separating the said first and second sheets. In a preferred embodiment, the pad is retained between front and back covers, and the sheets of expanded metal net are made from slit foil such as a magnesium alloy metal, while the inner core is a porous material such as fiberglass, cotton batting, or an assembly of miniature balls formed from expanded metal net.

The invention also comprises a method for protecting structures against the impact of explosions comprising interposing between said structure and said explosive a stratiform anti-explosion pad of the nature described above.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional elevation of the anti-explosion pad of the present invention, showing the various component layers.

FIG. 2 is a cross-sectional elevation of an optional variation of the explosion pad of the present invention, showing the inclusion of various additional optional layers.

FIG. 3 is a top view of a slitted metal foil sheet, which can be expanded by stretching to provide the expanded metal net usable in the present invention.

FIGS. 4 through 7 are top views of the expanded metal net, showing the changes in configuration as the slitted sheet is pulled to open up the expanded metal net.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings, the basic stratiform anti-explosion pad of the present invention is shown in FIG. 1, wherein the pad 10 contains sheets 3 and 4 made of expanded metal net and separated from each other by an inner core 5 made of an air-permeable material. Although not essential to the invention, it is desirable for certain purposes to enclose the above pad between front and back

covers 6 and 7 to maintain the integrity of the pad and prevent slipping or shifting of the elements. For this purpose, the front and back covers 6 and 7 may be bound together by stitching, stapling or other known fastening means at seams 8 and 9.

The expanded metal employed in sheets 3 and 4 is formed by slitting a continuous sheet of metal foil in a specialized manner and then stretching the slitted sheet to convert it to an expanded prismatic metal net having a thickness substantially greater than the thickness of the foil. Referring to the drawings, FIG. 3 shows a sheet of metal foil provided with discontinuous slits appropriate for the present invention. The length and width of the sheet may be chosen from any number of practical dimensions, depending on the size of the anti-explosion pad to be produced.

As noted in FIG. 3, sheet 10 is provided with discontinuous slits 11 in spaced apart lines which are parallel to each other but transverse to the longitudinal dimension of the sheet 10. The slits 11 in each line are separated by unslit segments or gaps 12, and it will be noted that the slits 11 in each line are offset from the slits 11 in adjacent lines. Similarly, the gaps 12 in each line are offset from the gaps 12 in adjacent lines. The lines of slits run parallel to the longitudinal edges 13 and 13A of the continuous sheet of metal foil. Apparatus for producing the slitted metal foil is described in detail in copending application Serial No. 07/605,540, filed October 29, 1990.

When the slitted metal foil as shown in FIG. 3 is stretched by subjecting it to longitudinal tension, it is converted into an expanded metal prismatic net, usable as elements 3 and 4 of FIG. 1 of the present invention. In the stretching procedure, the horizontal surfaces of foil are raised to a vertical position, taking on a honeycomb-like structure. This conversion is shown in FIGS. 4 through 7 of the drawings. The slitted metal foil 10 is shown in FIG. 4 prior to stretching. When longitudinal tension is applied in the direction of arrow 15, the slits 11 begin to open and are converted to eyes 16, and the product assumes the appearance shown in FIG. 5. The application of more tension causes a greater opening of the slits, and the product expands into the honeycomb-like, prismatic form shown in FIG. 6. When even further tension is applied, the configuration reaches its desired end point, as in FIG. 7. The conversion illustrated in FIGS. 4 through 7 is accompanied by an increase in thickness of the product, the final thickness of the honeycomb product being approximately twice the value of the space 14 between each line of slits.

For the anti-explosion pad usage of the present invention, it is desired that the metal foil be very thin and that the slits in each line and the spaces between the lines be very small. Thus, the thickness of the foil used to produce the metal net should be in the range between 0.028 and 1.0 mm, and the preferred thickness is between 0.028 and 0.2 mm. The length of each slit 11 is in the range between 1 and 2.5 cm, and the unslit sections or

gaps 12 between each slit are in the range between 2 to 6 mm long. The distance 14 separating lines of slits may be varied, depending on the thickness desired for the resulting expanded metal net. The distance 14 is ordinarily in the range between 1 and 4 mm, so that the thickness of the resulting expanded metal net is normally in the range between about 2 and 8 mm. The preferred value for distance 14 is either 1 mm or 2 mm.

The kind of metal used in the metal foil may be selected from a wide number of metals or alloys which may be produced in the form of a thin foil. For the purposes of the present invention, it is preferred to use alloys of magnesium with certain other compatible substances. Thus, for example, it is desirable to use an alloy of magnesium with substances such as aluminum, copper, zirconium, zinc, strontium, Rn(electron), silicon, titanium, iron, manganese, chromium, and combinations thereof. Alloys such as the above have the valuable characteristic of not only being lightweight, strong, elastic, heat-conductive, etc., but also the important characteristic of being nonflammable. A particularly useful combination is the alloy of magnesium with aluminum and copper. Another preferred combination is the alloy of magnesium with zirconium and strontium. To a somewhat lesser degree, alloys in which aluminum is substituted for the magnesium, are useful in the practice of the invention.

Further advantages are obtained if the expanded metal net is coated with materials such as an alkaline

bichromate or an oleate, which are effective in preventing any fire which may be initiated by detonation of the explosive. When heated, these materials emit a dense vapor which envelop the area and assist in preventing the ignition of construction materials in the area.

The inner core layer 5 may be any suitable air-permeable material such as fiberglass, cotton batting, or other similar non-woven substances. A particularly suitable core material for the layer 5 is an assembly of balls formed from expanded metal net. Such balls are most effective when formed in the shape of small ellipsoids. The ellipsoids are produced by cutting expanded metal net sheets (such as shown in FIGS. 3 through 7) into small segments and then mechanically forming them into the ellipsoid shape. The ellipsoids generally have a short diameter in the range of 20 to 30 mm, and a long diameter in the range of 30 to 45 mm. Apparatus for producing the ellipsoids is described in detail in copending application Serial No. 07/605,540, filed October 29, 1990.

The inner core layer 5 is preferably in the range between 1 to 6 inches thick. A thickness less than this provides diminishing protection, and thicknesses above this range, although effective, add bulkiness which is not practical under most conditions.

For certain uses, it is desirable that the layers 3, 4 and 5 be bound together in a cohesive pad by the use of front and back covers 6 and 7, which may be secured at seams 8 and 9. Any suitable material may used for the back

cover 7. However, it is essential that the front cover 6 be made of an air-permeable material such as a metal or fiber screen, which will allow the shock and heat waves of the bomb explosion to reach layers of expanded metal net 3 and 4 and allow said layers to diffuse and dissipate the said waves before they reach the structure to be protected. If the front cover 6 is a solid, impermeable material, the shock waves of the detonated explosive will exert their full unattenuated force against the impermeable surface and will destroy not only the protective pad but also the structure intended to be protected. It is essential therefore that the front cover be air-permeable, as indicated, and also that it be placed in position facing the direction from which the explosive forces will originate.

The invention is not limited to the use of only two layers of expanded metal net, separated by a single core layer. For some applications, involving heavier charges of explosives, it is advantageous to employ three or four layers of metal net, separated by matching cores of porous material. It is also useful in some environments to employ two or more sheets of metal net in contact with each other in a single layer.

FIG. 2 illustrates an embodiment of the invention, in which a double layer of expanded metal net is employed adjacent the front surface of the pad and additional layers of metal net, separated by layers of ellipsoid filling material, are laid up behind the front double layer. The extra layers of metal net and spacing material provide enhanced

protection against explosions. Referring to FIG. 2, the enhanced stratiform anti-explosion pad 17 contains layers 18, 19, 20 and 21 made of expanded metal net and separated from each other by inner cores 22, 23 and 24 made of an assembly of ellipsoids of the type described above. The front layer 18 is composed of a double layer of expanded metal net. The pad 17 is enclosed between front and back covers 25 and 26, which are bound together by stitching, stapling or other known fastening means such as seam 27. As indicated previously in connection with the embodiment of FIG. 1, it is essential that the front cover 25 be air-permeable and that it be placed facing the direction from which the explosive shock waves will come. Although the cores 22, 23 and 24 are illustrated in the form of ellipsoids, which are preferred, it will be understood that the core material may be any suitable air permeable material such as fiberglass, cotton batting, or other similar non-woven substances. A single pad may, for certain purposes, be made with different core materials in the various core layers, as for example in a pad with core 22 being ellipsoids and the remaining core layers being fiberglass.

Statiform pads of the nature described above provide remarkable protection against the destructive forces of an explosion. Although the proportion of expanded metal net to the overall weight of the structure being protected is very minute (i.e., between .05-1%), the special honeycomb configuration and the heat conductivity of the expanded metal net effectively dissipate the shock waves and thermal

effects of a close range bomb explosion. Thus, for example, a concrete block wall covered with the anti-explosion pad of the present invention, suffers no damage from a one-pound TNT bomb detonated 5 inches in front of the wall; whereas, without the pad, the wall is obliterated.

The anti-explosion pad may readily be applied to the surface of structures by means of nails, staples, adhesives, and the like. When in place, the invention has widespread applicability for the protection of structures against explosions. Applications in homes and commercial buildings include covering the walls of garages, furnace rooms, or other areas where fuel tanks or other explosive materials are located. In automobiles, the firewall between the engine compartment and the passenger area may be covered with the anti-explosive pad. For anti-terrorist purposes, the walls of airliner luggage compartments may readily be covered with the product of the invention, to contain and suppress the shock and concussion of a bomb and prevent damage to the controls and other vital structural elements of the plane. The material may be fabricated into walking shields for use by police and firemen at risk from bomb explosions.

The following examples describe specific embodiments which illustrate the invention but should not be interpreted as limiting the scope of the invention:

EXAMPLE 1

A wall 6 feet long, 6 feet high, and 6 inches thick was constructed of concrete block, resting on a 6 inch poured concrete footing in the ground. The entire front surface of this wall was covered with a pad having the construction shown in FIG. 1 of the drawings.

The expanded metal net used in the two layers of the pad was made from an alloy comprising 0.25% Si, 0.3% Fe, 0.01% Cu, 0.01% Mn, 10% Al, 0.01% Zn, 0.1% Ti, and the remainder Mg. The metal foil was .1 mm thick, and in its expanded form the metal net was 2 mm thick. The inner core was a 2 inch thick layer of fiberglass. The padding material had front and back covers made of metal screening with a mesh of 4 microns.

A one pound bomb of TNT (trinitrotoluene) in a plastic container was placed on the ground 5 inches from the covered surface of the wall and detonated. In spite of the extreme impact, the wall remained intact and showed no signs of damage. The front surface of the anti-explosive pad showed only slight scarring.

Following this, the pad was removed from the wall, and a second one pound bomb of TNT in a plastic container was placed on the ground 5 inches from the wall and detonated. The wall was obliterated.

EXAMPLE 2

A wall was built, having the same dimensions, materials and configuration as in Example 1. The wall was cov-

ered with an anti-explosion pad having the structure shown in FIG. 2 of the drawings.

The expanded metal net used in the pad was made from an alloy comprising 0.25% Si, 0.3% Fe, 0.01% Cu, 0.01% Mn, 10% Al, 0.01% Zn, 0.1% Ti, and the remainder Mg. The metal foil was .1 mm thick, and in its expanded form the metal net was 2 mm thick. The metal foil was coated with an oleate composition. Each of the inner cores was a 1 inch thick assembly of ellipsoids made from the same material as the layers of expanded metal net. The padding material had front and back covers made of metal screening with a mesh of 4 microns.

A two pound bomb of TNT (trinitrotoluene) in a metal shell was placed on the ground 5 inches from the covered surface of the wall and detonated. In spite of the extreme impact, the wall remained intact and showed no signs of damage or burning. The front surface of the anti-explosive pad showed only slight scarring.

Although preferred embodiments of the invention have been described herein in detail, it will be understood by those skilled in the art that variations may be made thereto without departing from the spirit of the invention.

WHAT IS CLAIMED IS:

1. A stratiform anti-explosion pad comprising a first sheet of expanded metal net, a second sheet of expanded metal net, and an inner core layer of air-permeable material separating said first and second sheets.

2. The anti-explosion pad of Claim 1 wherein said expanded metal net is made from magnesium alloy foil.

3. The anti-explosion pad of Claim 2 wherein said magnesium alloy foil has a thickness in the range from about 0.028 to 0.5 mm.

4. The anti-explosion pad of Claim 1 wherein said expanded metal net has a thickness of about 2 to 8 mm in its expanded form.

5. The anti-explosion pad of Claim 1 wherein said inner core of air-permeable material comprises fiberglass.

6. The anti-explosion pad of Claim 1 wherein said inner core of air-permeable material comprises cotton batting.

7. The anti-explosion pad of Claim 1 wherein said inner core of air-permeable material comprises an assembly of balls formed from expanded metal net.

8. The anti-explosion pad of Claim 1 wherein said pad is retained between front and back covers, said front cover comprising an air-permeable material.

9. The anti-explosion pad of Claim 8 wherein said front cover comprises a woven screen.

10. A stratiform anti-explosion pad for use in protecting structures against the impact of explosions, said pad having its component layers bound together to form a unified structure containing:

a. a front cover layer formed of an air-permeable material

b. a first anti-explosion layer comprising at least 2 sheets of expanded metal net laid up in contact with each other and adjacent said front cover layer;

c. a second anti-explosion layer comprising at least 1 sheet of expanded metal net, said second anti-explosion layer being spaced apart from said first anti-explosion layer;

d. an inner core layer of air permeable material separating said first and second anti-explosion layers; and

e. a back cover layer bound to and cooperating with said front cover layer to provide a unified structure.

11. A stratiform anti-explosion pad for use in protecting structures against the impact of explosions, said pad having its component layers bound together to form a unified structure containing:

a. a front cover layer formed of an air-permeable material

b. a first anti-explosion layer comprising at least 2 sheets of expanded metal net laid up in contact with each other and adjacent said front cover layer;

c. a second anti-explosion layer comprising at least 1 sheet of expanded metal net, said second anti-explosion layer being spaced apart from said first anti-explosion layer;

d. a first inner core layer of air permeable material separating said first and second anti-explosion layers;

e. a back cover layer bound to and cooperating with said front cover layer to provide a unified structure; and

f. a second inner core layer of air-permeable material separating said second anti-explosion layer and said back cover layer.

12. A method of protecting a structure against the explosive impact of an explosive, comprising interposing between said structure and said explosive a stratiform anti-explosion pad comprising a first sheet of expanded metal net, a second sheet of expanded metal net, and an inner core

layer of air-permeable material separating said first and second sheets.

13. The method of Claim 12 wherein said expanded metal net is made from magnesium alloy foil.

14. The method of Claim 13 wherein said magnesium alloy foil has a thickness in the range from about 0.028 to 0.5 mm.

15. The method of Claim 12 wherein said expanded metal net has a thickness of about 2 to 8 mm in its expanded form.

16. The method of Claim 12 wherein said inner core of air-permeable material comprises fiberglass.

17. The method of Claim 12 wherein said inner core of air-permeable material comprises cotton batting.

18. The anti-explosion pad of Claim 12 wherein said inner core of air-permeable material comprises an assembly of balls formed from expanded metal net.

19. The anti-explosion pad of Claim 12 wherein said pad is retained between front and back covers, said front cover comprising an air-permeable material.

20. The anti-explosion pad of Claim 19 wherein said front cover comprises a woven screen.

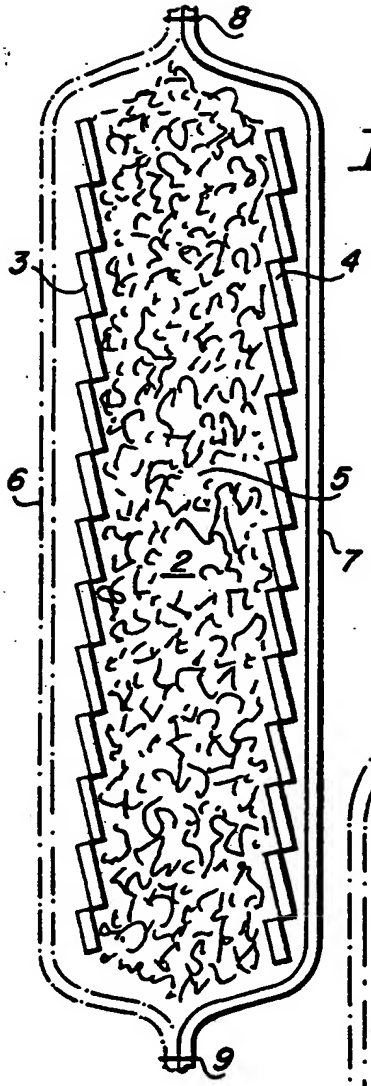

FIG. 1

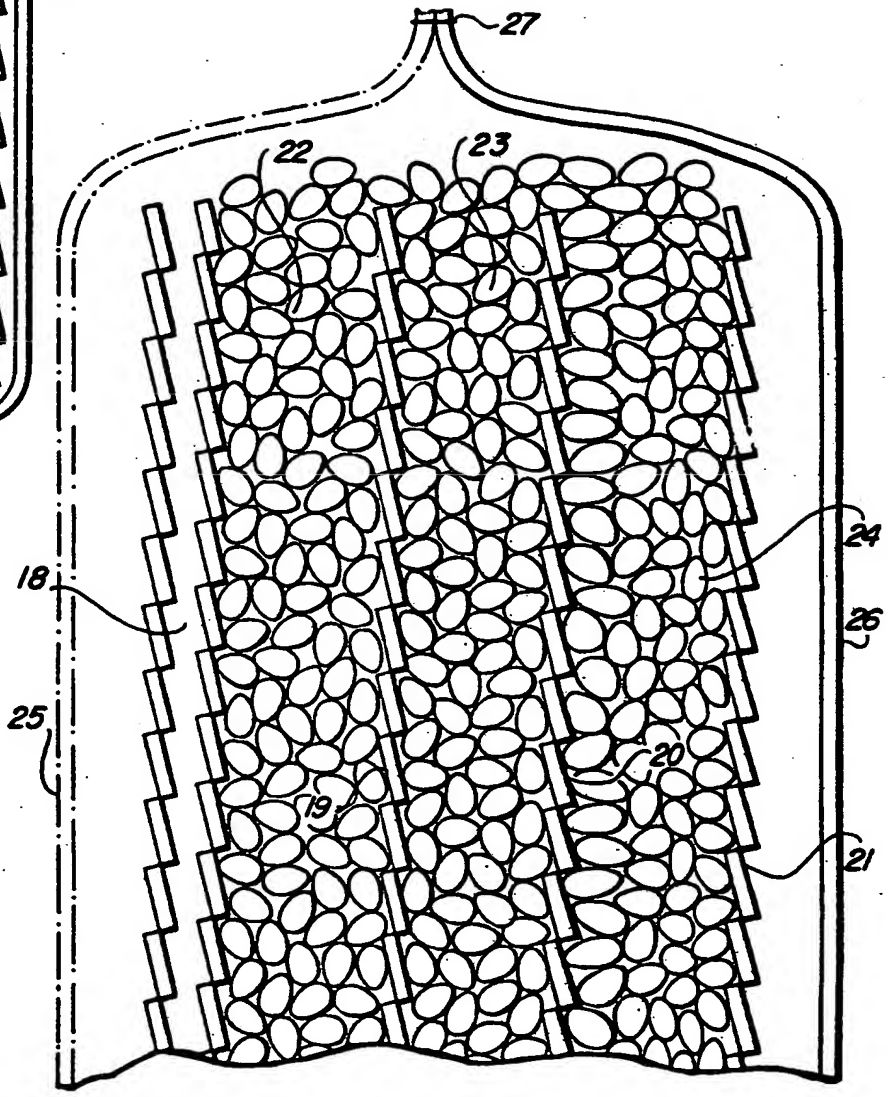

FIG. 2

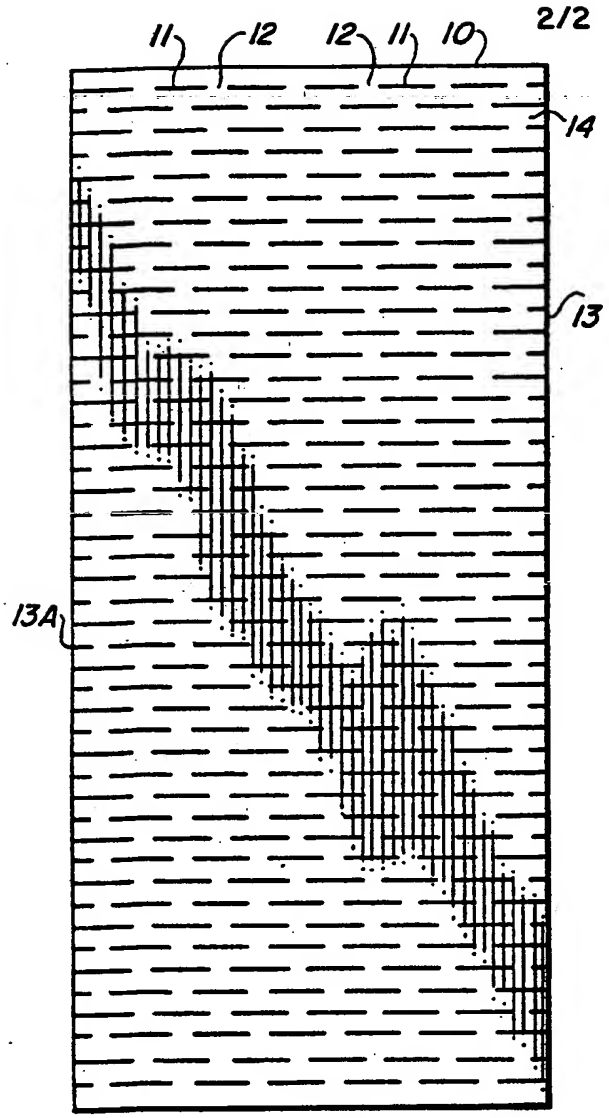

FIG. 3

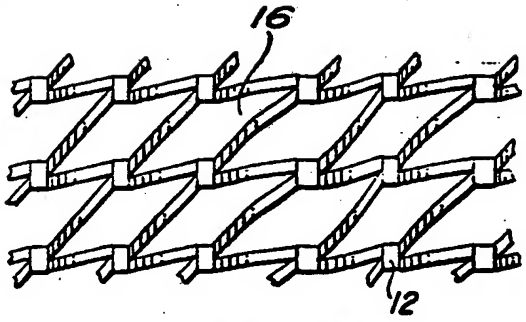

FIG. 6

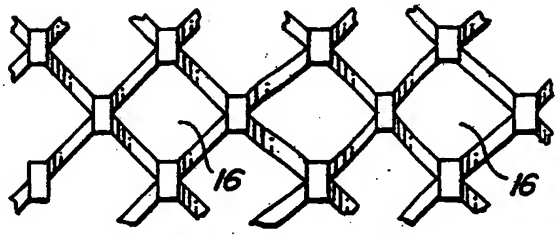

FIG. 7

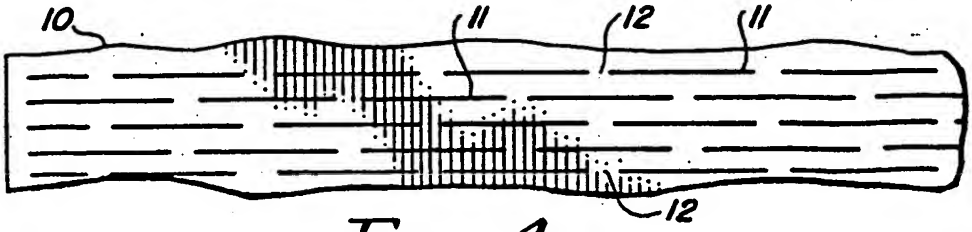

FIG. 4

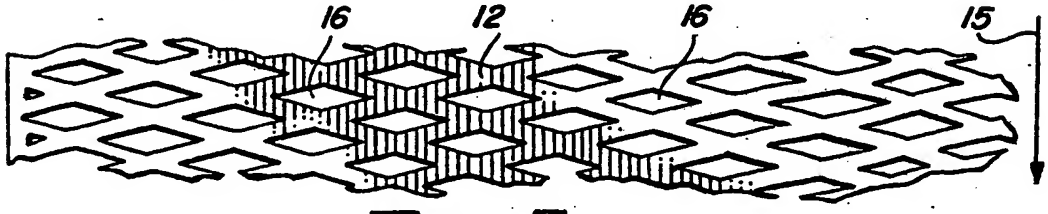

FIG. 5

INTERNATIONAL SEARCH REPORT

PCT/US92/09221

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :E06B 9/00
US CL :109/49.5, 83, 84
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 109/49.5, 83, 84, 80, 85, 65

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Anti-Explosion, Magnesium, Metal, Protection, Explosion

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,727,789 (KATSANIS ET AL) 01 MARCH 1988	1-20
Y	US, A, 4,828,932 (MORIMOTO ET AL) 09 MAY 1989	1-20
Y	US, A, 3,431,818 (KING) 11 MARCH 1969	5-7,16-18
A	US, A, 3,356,256 (SZEGO) 05 DECEMBER 1967	1, 10-12
A	GB, A, 554,562 (BENNIE) 09 JULY 1943	1-20
A	US, A, 4,149,649 (SZEGO) 17 APRIL 1979	1-20
A	US, A, 3,648,613 (CUNN) 14 MARCH 1972	1-20

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Date of the actual completion of the international search	Date of mailing of the international search report
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